8/PART

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DESCRIPTION

Speaker Apparatus

FIELD OF THE INVENTION

The present invention relates to a speaker apparatus used for a television receiver (TV), and more particularly to a speaker apparatus that comprises a microphone for detecting reproduced sound from a speaker unit and corrects this reproduced sound based on this detection signal.

BACKGROUND OF THE INVENTION

It is known that a speaker apparatus having the following structure contributes the improvement of acoustic characteristics. A horn or an acoustic pipe whose opening is rectangular is mounted in front of a speaker unit, and sound wave generated in the speaker unit is guided to the opening of the acoustic pipe. A microphone is mounted in this acoustic pipe and is connected to an amplifier for putting an input signal into the speaker unit through a feedback circuit.

The prior art discussed above is shown in Fig.8 and Fig.9. Fig.8 is a horizontal sectional view of a conventional acoustic pipe type speaker apparatus with a sound feedback system, and Fig.9 shows acoustic output characteristics thereof.

In Fig. 8, speaker unit 1 produces sound wave and is connected with acoustic pipe 2. Sound absorbing material 3 is

disposed for damping resonance on both sides of acoustic pipe 2. In acoustic pipe 2, microphone 4 for detecting an acoustic output signal is placed near speaker unit 1. When a signal is fed into speaker unit 1, speaker unit 1 radiates an acoustic output, and the acoustic output is lead through acoustic pipe 2 and radiated from the opening of acoustic pipe 2.

At this time, for preventing a speaker apparatus from having a reproduced-sound-pressure frequency characteristic with radical peaks and dips caused by standing wave occurring inside acoustic pipe 2 or standing wave due to the length of acoustic pipe 2, these standing waves must be damped by sound absorbing material 3. However, this countermeasure is insufficient, and therefore, microphone 4 detects the acoustic output, i.e. the unrestrainable standing waves, and feeds them back to an amplifier that input an signal into speaker unit 1. The standing waves occurring in acoustic pipe 2 are thus damped, so that a flat reproduced sound pressure frequency characteristic is obtained.

Frequency characteristics of speaker unit 1 and acoustic pipe 2 can be corrected by placing microphone 4 in front of and close to speaker unit 1. The characteristic of acoustic pipe 2 can be corrected by placing microphone 4 at a position where sound pressure of primary resonance of acoustic pipe 2 is maximum, i.e. at a position of one third of the length of

acoustic pipe 2. The characteristic can be controlled from a low frequency region to the primary resonance region of acoustic pipe 2 by placing microphone 4 near the terminal of acoustic pipe 2.

The conventional speaker apparatus discussed above hardly keeps sufficient oscillation margin, because microphone 4 detects acoustic outputs of second and higher resonance generated in acoustic pipe 2, also detects resonance occurring in a closed space orthogonal to the longitudinal direction of acoustic pipe 2, and feeds them back to the amplifier. In addition, the shape of acoustic pipe 2 becomes to be complicated for damping the standing wave, and the speaker apparatus becomes expensive due to the use of sound absorbing material 3 or the like.

The present invention aims to address these problems, and provides a speaker apparatus that has a simply structured acoustic pipe and has a stable acoustic characteristic.

DISCLOSURE OF THE INVENTION

For addressing the problems discussed above, a speaker apparatus of the present invention comprises the following elements:

an amplifier for receiving an input signal,

a speaker unit for reproducing an output of the amplifier,

a microphone for detecting an acoustic output radiated from the speaker unit, and

a feedback circuit for feeding the acoustic output signal detected by the microphone back to the input side of the amplifier;

wherein an acoustic pipe for guiding sound wave is placed in front of the speaker unit. In addition, the microphone for correcting primary resonance is placed at a position where sound pressure of at least one of second and higher resonance of this acoustic pipe is low enough to prevent oscillation. The speaker apparatus can thus obtain a stable characteristic by restraining the influence of the primary resonance that is the largest factor to a sound pressure frequency characteristic of the speaker apparatus employing the acoustic pipe.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig.1 is a horizontal sectional view of a speaker apparatus in accordance with an embodiment of the present invention.

Fig.2 is a block diagram of the same speaker apparatus of Fig.1.

Fig.3 is an acoustic output characteristic diagram of the speaker apparatus of Fig.1.

Fig.4A is a horizontal sectional view of a speaker apparatus in accordance with another embodiment.

Fig.4B is a vertical sectional view of the speaker apparatus of Fig.4A.

Fig.5A is a horizontal sectional view of a speaker apparatus in accordance with yet another embodiment.

Fig.5B is a vertical sectional view of the speaker apparatus of Fig.5A.

Fig.6 is a vertical sectional view illustrating a mounting means of a microphone in an acoustic pipe, i.e. an important element of still another embodiment.

Fig.7 is a schematic diagram illustrating a speaker apparatus disposed in a TV receiver of still another embodiment.

Fig.8 is a horizontal sectional view of a conventional speaker apparatus.

Fig.9 is an acoustic output characteristic diagram of the conventional speaker apparatus.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Embodiments of the present invention are described hereinafter with reference to Fig.1 to Fig. 7.

In the following explanation, the same elements used in the prior art are denoted with the same reference numerals.

First Embodiment

A first embodiment of the present invention is described with reference to Fig. 1 to Fig.3.

Fig. 1 is a horizontal sectional view showing a configuration of speaker unit 1 combined with an acoustic pipe that is an important element of a speaker apparatus and is used for guiding sound wave. Fig.2 is a block diagram of an acoustic circuit using the speaker apparatus, and Fig.3 is an acoustic output characteristic thereof.

First, an entire configuration of the speaker apparatus is described with reference to Fig.2.

In Fig.2, speaker unit 1 is coupled to acoustic pipe 2 in front thereof, and microphone 4 is mounted inside acoustic pipe 2. Sound wave radiated from speaker unit 1 is detected by a microphone 4 in acoustic pipe 2 and a signal travels through microphone amplifier 10 and adder/subtracter 11, and is mixed with an external input signal in subtracter 12 to correct the input signal. The signal is then amplified by power amplifier 13, and is put into speaker unit 1.

As discussed above, the speaker apparatus undergoes frequency correction of an acoustic output using the sound wave radiated from the speaker unit 1 with a feedback circuit. Next, a position of microphone 4 in acoustic pipe 2, i.e. an important element, is described, and a means for correcting

primary resonance, this is a heart of the invention, is described.

Regarding a positional relation between speaker unit 1 and acoustic pipe 2, acoustic pipe 2 for guiding the sound wave is placed in front of speaker unit 1 mounted to a speaker box (not shown), and sound is radiated from an opening shaped in a narrow rectangular slit. Microphone 4 is placed near a position (node position) where sound pressures of second and third pipe resonance occurring in acoustic pipe 2 become in minimum. This position is a common position that is not subjected to the pipe resonance and is near to the positions where respective sound pressures of second and third resonance are minimum, because sound pressures of second and third resonance generally become minimum at different positions. The frequencies of the second and third resonance occurring responsive to the length "La" which is a distance from the opening of speaker unit 1 to the opening of the acoustic pipe 2 are calculated using the following equation:

$$fa = (n+1)\, C \,/\, 4\, La$$

where "fa" is pipe resonance frequency, "n" takes 2 for second resonance and 3 for third resonance, "C" is sound velocity, and La is pipe length.

Microphone 4 detects only primary component of pipe resonance from the acoustic output signal radiated from

speaker unit 1 combined with acoustic pipe 2, and feeds the detected acoustic output signal back to subtracter 12.

Fig.2 is the block diagram of the speaker apparatus, and a relation between input and output satisfies the following equation:

$$Vout / Vin = A / (1+A \bullet T(S))$$

where Vout is an output voltage, Vin is an input voltage, A is total amplification factor of the amplifier, and T(S) is a transfer function.

Assuming T(S) is substantially a transfer function of speaker unit 1 because a characteristic of microphone 4 is almost flat, T(S) becomes "−1" due to phase shift of second and third pipe resonance of speaker unit 1 and acoustic pipe 2.

In other words, denominator becomes null (0) to provide a condition of oscillation.

But, in the present invention, microphone 4 does not detect the second and third pipe resonance occurring in acoustic pipe 2, thus T(A) hardly takes "−1", and this allows the stable feedback control.

Fig.3 shows the acoustic output characteristic of the embodiment. The prior art characteristic shown in Fig.9 includes the second and third pipe resonance ((a) and (b) portions in Fig.9), but the characteristic shown in Fig.3 does not include them.

Thus, the characteristic can be improved by detecting only primary resonance of pipe resonance occurring in acoustic pipe 2 with microphone 4 and by feeding it back. Depending on a required acoustic characteristic, acoustic pipe 2 can be constituted without using a sound absorbing chamber or sound absorbing material that employs Helmholtz resonance and is used for damping resonance in a conventional pipe. As a result, efficiency of a design of acoustic pipe 2 is improved, and a greatly economical speaker apparatus can be provided because a die structure or the like is simple.

In the embodiment, microphone 4 is placed at the position which is not affected by the second and third pipe resonance. But, if influence of either of the pipe resonance can be neglected in relation to the acoustic characteristic, microphone 4 may be placed only near a position (sound pressure does not cause pipe resonance) where sound pressure of the either of the pipe resonance frequency is minimum.

Microphone 4 may be placed at a position where second and higher pipe resonance can be neglected in the characteristic of employed acoustic pipe 2.

Second Embodiment

A second embodiment of the present invention is described with reference to Fig.4A and Fig.4B.

Fig.4A is a horizontal sectional view showing a configuration of speaker unit 1 combined with acoustic pipe 2 that is the important element and is used for guiding sound wave. Fig.4B is a vertical sectional view thereof. Only a different point with the embodiment 1 is described with reference to Fig.4B. Resonance frequencies ~~fa~~ fb and ~~fb~~ fc occurring in a closed space orthogonal to the longitudinal direction of acoustic pipe 2 are calculated using the following equations:

$$f_b = (n+1)\, C / 2\, L_b, \text{ and } f_c = (n+1)\, C / 2\, L_c,$$

where, ~~fa~~ fb is pipe resonance frequency resonating orthogonal to the longitudinal direction of the acoustic pipe, ~~fb~~ fc is pipe resonance frequency a1 ~~at a position where fa is rotated by 90°~~, n takes 2 for second resonance and 3 for third resonance, C is sound velocity, Lb is length orthogonal to the longitudinal direction of the acoustic pipe, and Lc is length in the direction where Lb is rotated by 90°. Microphone 4 is placed near a position (node position) where sound pressures of the resonance frequencies fa and fb occurring in the closed space orthogonal to the longitudinal direction of acoustic pipe 2 are respectively minimum. This position is a common position that is not subjected to the pipe resonance and is near to the positions where respective sound pressures of respective frequencies are at minimum, because the sound pressures of the two-direction resonance generally become minimum at

different positions. Microphone 4 is prevented from detecting the resonance frequency components occurring in the closed space orthogonal to the longitudinal direction of acoustic pipe 2 in the acoustic output signal radiated from speaker unit 1 combined with acoustic pipe 2, and feedback is performed using the acoustic output signal from microphone 4.

Since resonance occurring in the closed space orthogonal to the longitudinal direction of acoustic pipe 2 are not detected by microphone 4 in the present invention, T(S) hardly takes "−1" and this allows the stable feedback control. Thus, resonance frequencies occurring in the closed space in acoustic pipe 2 is not detected, and as a result, the stability of the feedback can be secured.

Third Embodiment

A third embodiment of the present invention is described with reference to Fig.5A and Fig.5B.

Fig.5A is a horizontal sectional view showing a configuration of speaker unit 1 combined with acoustic pipe 2 that is an important element and is used for guiding sound wave. Fig.5B is a vertical sectional view of the third embodiment. The third embodiment has both features of the first and the second embodiments. Microphone 4 is placed at a position where it is not affected by the second and third pipe

resonance depending on the length of acoustic pipe 2 and, also, by resonance orthogonal to the longitudinal direction of acoustic pipe 2. Microphone 4 detects only primary resonance of acoustic pipe 2, and does not detect resonance frequency occurring in the closed space orthogonal to the longitudinal direction of acoustic pipe 2. This position, where microphone 4 is disposed, is not subjected to the pipe resonance, and yet close to the positions (node positions) where sound pressures of respective resonance frequencies are minimum. Thus, the stability of the feedback can be secured.

Fourth Embodiment

A forth embodiment of the present invention is described with reference to Fig.6 and Fig.7.

Fig.6 is a sectional view of the embodiment near acoustic pipe 2, and Fig.7 is a sectional view when the speaker apparatus is mounted to a TV receiver. The embodiment shows a mounting means for microphone 4 more specifically than those in each embodiment discussed above. Bracket 5 is mounted to a wall of acoustic pipe 2 via a fastening means 5a, and bracket 5 can set microphone 4 with ease in respective embodiments 1 to 3 at a given position.

The speaker apparatus is constituted so that it is mounted to the TV and placed between cathode ray tube 8 (CRT) and

television cabinet 6. Even if the length of sound guiding portion 7 of television cabinet 6 is changed, and this change causes the length of the acoustic pipe of the speaker apparatus to be modified, and thus the condition of the resonance frequency changes, the position of microphone 4 can be easily shifted by replacing bracket 5 with an appropriate one. In other words, the stability of the feedback circuit can be improved by shifting the setting position of microphone 4 to the position described in embodiments 1 to 3.

When a rib or the like is formed in acoustic pipe 2 for reinforcement, and thus the resonance system is increased in acoustic pipe 2, the present invention is still applicable

INDUSTRIAL APPLICABILITY

First, a speaker apparatus of the present invention comprises the following elements:

an amplifier for receiving an input signal,

a speaker unit for reproducing an output signal supplied from the amplifier,

a microphone for detecting an acoustic output radiated from the speaker unit, and

a feedback circuit for feeding the acoustic output signal detected by the microphone back to the input side of the amplifier.

In addition, the speaker apparatus is constituted so that an acoustic pipe for guiding sound wave is mounted in front of the speaker unit and the microphone is placed at a position where sound pressure of at least one of second and higher pipe resonance of this acoustic pipe is low enough not to cause oscillation. Thus, influence of second and higher pipe resonance is reduced to improve stability of the feedback circuit and to allow increase of feedback amount, and therefore, a speaker apparatus with an excellent acoustic characteristic is obtainable.

Second, in the configuration discussed above, when the microphone is placed at a position where sound pressure of at least one of second and third pipe resonance is low enough not to cause oscillation, influence of at least one of influential second and third pipe resonance is reduced and a speaker apparatus with a more excellent acoustic characteristic is obtainable.

Third, a speaker apparatus comprises the following elements:

an amplifier for receiving an input signal,

a speaker unit for reproducing an output signal supplied from the amplifier,

a microphone for detecting an acoustic output emitted from the speaker unit, and

a feedback circuit for feeding the acoustic output signal detected by the microphone back to the input side of the amplifier.

In addition, the speaker apparatus is constituted so that an acoustic pipe for guiding sound wave is mounted in front of the speaker unit and the microphone is placed at a position where at least sound pressure of resonance occurring in a closed space of this acoustic pipe is low enough not to cause oscillation. Thus, the stability of the feedback circuit can be improved even in the closed space, a feedback amount can be increased, and therefore, a speaker apparatus with an excellent acoustic characteristic is obtainable.

Fourth, a speaker apparatus comprises the following elements:

an amplifier for receiving an input signal,

a speaker unit for reproducing an output signal supplied from the amplifier,

a microphone for detecting an acoustic output radiated from the speaker unit, and

a feedback circuit for feeding the acoustic output signal detected by the microphone back to the input side of the amplifier.

In addition, the speaker apparatus is constituted so that an acoustic pipe for guiding sound wave is mounted in front of the

speaker unit and the microphone is placed at the following position: sound pressure of at least one of second and third pipe resonance of this acoustic pipe is low enough not to cause oscillation; and at least sound pressure of resonance occurring in the closed space of this acoustic pipe is low enough to prevent oscillation. Thus, influences of at least one of second and third pipe resonance in the longitudinal direction of the acoustic pipe and of resonance occurring in the closed space thereof are both reduced, and therefore, a speaker apparatus with an excellent acoustic characteristic is obtainable.